water. By increasing the flow rate from 5 to 25 mL per minute, the time required for the separation is reduced from around four minutes to less than one minute. The polymer separation blocks formulated in accordance with the present invention, when used in combination with a through-substrate multi-nozzle array electrospray device, optimizes the higher flow rates achievable with the multi-nozzle array which can be used to increase sample analysis speed.

[0209] In accordance with the present invention, through-substrate separation is integrated with high density arrays of electrospray devices, which also have through-substrate electrospray channels. In this manner, high density arrays of through-substrate separation channels can be oriented parallel to corresponding electrospray channels of high density arrays of electrospray devices. Such configurations achieve separation/detection density capabilities and flow through volumes not possible with conventional technology. Through-substrate channels are characterized by channels extending from one surface through the width of the substrate to the other surface. Through-substrate channels can be distinguished from 3-sided or open channels which are typically etched on the surface of the substrate. Open channels are typically closed by placing a cover plate over the surface channels of the substrate.

[0210] Sample detection from multiple electrospray nozzles can be achieved from the sequential or simultaneous spraying of an array of electrospray nozzles. For sequential spraying, a detector such as a mass spectrometer can be placed in communication with a first electrospray of from, for example, an array of 8 electrospray devices. The electrospray is passed into the inlet of the mass spectrometer and analytes present in the electrospray are detected. The array of nozzles are then moved to place a second one of the 8 devices in communication with the mass spectrometer. Analytes present in the second electrospray are detected in a similar manner. The array of electrospray devices are moved in desired sequence until all electrosprays are analyzed.

[0211] For simultaneous spraying, fluid is simultaneously sprayed through each of the nozzles in the array. The analytes are analyzed by sweeping the detector, for example a mass spectrometer, across the face of the nozzle surface. The nozzles are spaced apart in a manner so as to readily correlate the detected sample with each of the corresponding nozzle samples. Processing capacity and time can thus be increased over that compared to the previous method. Alternately, when it is not necessary to distinguish between each nozzle spray, multiple electrosprays from the nozzle array can be simultaneously sprayed and detected to further increase processing capacity.

[0212] Accordingly, through-substrate separation integrated with through-substrate electrospray formatted in a high density array system in accordance with the present invention achieves an increased flow rate, volume, and density detection capabilities previously unachievable in the art.

[0213] Although the invention has been described in detail for the purpose of illustration, it is understood that such detail is solely for that purpose, and variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention which is defined by the following claims.

What is claimed is:

1. An electrospray device comprising:

a substrate having:

a) an injection surface;

b) an ejection surface opposing the injection surface, wherein the substrate has at least one spray unit which comprises:

an entrance orifice on the injection surface,

an exit orifice on the ejection surface,

a channel extending through the substrate between the entrance orifice and the exit orifice, and

a recess extending into the ejection surface and surrounding the exit orifice;

c) separation material associated with said electrospray device at a location suitable to effect chromatographic separation of analytes passing through said electrospray device; and

d) an electric field generating source positioned to define an electric field surrounding at least one exit orifice.

2. The electrospray device according to claim 1, wherein the separation material comprises a porous polymer, polymer monolith, non-monolith polymer particles, particles containing a stationary phase, silica particles, non-porous silica, or silica particles encapsulated in a polymer matrix.

3. The electrospray device according to claim 1, wherein the electric field generating source comprises:

a first electrode attached to said substrate to impart a first potential to said substrate and

a second electrode to impart a second potential, wherein the first and the second electrodes are positioned to define an electric field surrounding the exit orifice.

4. The electrospray device according to claim 3, wherein the first electrode is electrically insulated from fluid passing through said electrospray device and the second potential is applied to the fluid.

5. The electrospray device according to claim 3, wherein the first electrode is in electrical contact with fluid passing through said electrospray device fluid and the second electrode is positioned on the ejection surface.

6. The electrospray device according to claim 3, wherein application of potentials to said first and second electrodes causes fluid passing through said electrospray device fluid to discharge from the exit orifice in the form of a spray.

7. The electrospray device according to claim 3, wherein application of potentials to said first and second electrodes causes fluid passing through said electrospray device fluid to discharge from the exit orifice in the form of droplets.

8. The electrospray device according to claim 1, wherein said substrate is silicon.

9. The electrospray device according to claim 1, wherein said substrate is polymeric.

10. The electrospray device according to claim 1, wherein said substrate is glass.

11. The electrospray device according to claim 1 wherein said substrate is an integral monolith.

12. The electrospray device according to claim 1, wherein the entrance orifice, the exit orifice, and the channel have a coating of an insulating material.